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PATENT COOPERATION TREATY

EINGEGANGEN

18. Mai 2004

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

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PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	17.05.2004
Applicant's or agent's file reference MAN-P4 PCT	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IB 02/00584	21.02.2002	21.02.2002

Applicant
MANNHART, Jochen Dieter et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international preliminary examining authority:	Authorized Officer
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PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference MAN-P4 PCT	**FOR FURTHER ACTION** See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/IB 02/00584	International filing date *(day/month/year)* 21.02.2002	Priority date *(day/month/year)* 21.02.2002
International Patent Classification (IPC) or both national classification and IPC H01L39/14		
Applicant MANNHART, Jochen Dieter et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 7 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the opinion
   II ☐ Priority
   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☐ Lack of unity of invention
   V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   VI ☐ Certain documents cited
   VII ☐ Certain defects in the international application
   VIII ☐ Certain observations on the international application

Date of submission of the demand 03.07.2003	Date of completion of this report 17.05.2004
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Meul, H Telephone No. +49 89 2399-2494

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-21,23-25
	No:	Claims	22
Inventive step (IS)	Yes:	Claims	1-21,23-25
	No:	Claims	22
Industrial applicability (IA)	Yes:	Claims	1-25
	No:	Claims	

2. Citations and explanations

   see separate sheet

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IB 02/00584

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1-5, 7-16	as originally filed
6, 6a	received on 30.04.2004 with letter of 28.04.2004

Claims, Numbers

1-25	received on 30.04.2004 with letter of 28.04.2004

Drawings, Sheets

1-5	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

Re Item V

Reasoned statement under Article 35 (2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

V.1

Novelty and inventive step of the subject-matter of claims 1-21 and 23-25

Technical field

The invention relates to an extended polycrystalline superconductor and a method of making same.

Closest prior art

The paper by T. Muroga et al. in Physica C, vol. 309, no. 3-4, pages 236-244 (=D1) discloses an extended polycrystalline superconductor in tape form (see samples G and I in Table 1 and Fig. 10 of D1) comprising a substrate (Ag foil), said substrate having deposited thereon a superconducting Bi-2212 layer. The tape having a length of several centimetres may be folded onto itself along the long direction of the tape such that the surfaces of the superconducting layer are in contact with each other.

Technical problem

To provide superconducting conductors having larger lengths at competitive costs

Solution

An extensive superconducting contact extending over at least a fraction of f = 0.3 of the length and width of the polycrystalline superconductor is established between the surfaces of either two superconducting layers on two substrates (see claim 1) or between surfaces or surface portions of one or more superconducting $REBa_2Cu_3O_7$ layer on one substrate of at least 1 m length (see claim 2 for the superconductor and claim 23 for the corresponding fabrication method). These solutions are based on the understanding that the critical current density of long conductors can be increased by joining two superconductors with their superconducting sides facing each other, such that the effective grain boundary area is enhanced and a good superconducting contact is established, whereby the supercurrent can meander along the layers, in part bypassing the grain boundaries within one layer by shifting into grains of the other layer.

Assessment

None of the presently available prior art documents discloses or fairly suggests an extended polycrystalline superconductor comprising an extensive superconducting contact established by contacting the surfaces of two superconducting layers formed on two separate substrates over at least 30 % of the length and width of the superconductor. The superconductor of claim 1 is therefore novel and inventive. Moreover, none of the available prior art documents discloses or fairly suggests an extended polycrystalline superconductor of at least 1 m length comprising a superconducting $REBa_2Cu_3O_7$ layer on one substrate with a superconducting contact extending over at least 30 % of the length and width of the superconductor and being established between surfaces or surface portions of the superconducting layer(s). More specifically, D1 does not teach that long superconductors with increased critical current density can be produced by providing an extensive superconducting contact allowing meandering across the grain boundaries associated with the transition from one layer or layer portion to the other on top thereof.
WO-01/08169 A (=D2) does not disclose an extensive superconducting contact formed over at least 30 % of the length and width of the superconductor. Superconducting interlayer connections are provided in the form of via holes occupying a much smaller contact area.
WO-01/08233 A (=D3) does not disclose any extensive superconducting contact between superconducting layers.

Therefore, the subject-matter of independent claims 1, 2 and 23 is novel and involves an inventive step. Dependent claims 3-21 and 24-25 define advantageous developments of the superconductors of claims 1 and 2 and the method of claim 23, respectively, and as such also meet the requirements of the PCT with respect to novelty and inventive step.

Clarity

Claim 2 lacks clarity (Article 6 PCT) because the wording "between the surface(s) of said superconducting layer(s)" is vague and misleading for the singular form. It should have been explicitly specified in case of only one superconducting layer that the superconducting contact is established between different areas of the layer which contact each other due to a folding of the layer onto itself (see p. 15, l. 12-16 of the description).

V.2

Noncompliance of novelty and/or inventive step of the subject-matter of claim 22

The subject-matter of claim 22 cannot be distinguished from the disclosure of the document WO 01/08169 A (=D2) for the following reasons:

D2 discloses a method of making an extended superconductor (see Figs. 4 and 6 and the related text of D2), the method comprising depositing two superconducting layers (47, 49) onto at least one substrate and establishing a superconducting contact between the surfaces of said superconducting layers, said superconducting contact extending over at least a predetermined fraction of the length and width of said superconducting layers (see p. 33, l. 19-23 and p. 34, l. 4-6 of D2). The term "extensive superconducting contact" used in claim 22 is not suited to clearly and unambiguously distinguish the method of claim 22 from that described in D2.
It should be also pointed out that each known heterogeneous multilayer fabrication with two different superconducting layer materials alternately deposited on a substrate could be read upon present claim 22 since one layer material may be considered as "extended superconducting contact" for the other material.

Therefore, the method of claim 22 lacks novelty over D2 (Article 33.2 PCT).

New page 6

tion method (ISD). In these techniques the buffer layer is textured during growth. This is done in the ISD-process by using a shallow angle between the incoming beam of adatoms and the substrate surface, and in the IBAD technique by irradiating the growing film with additional ions. The critical current densities of the superconducting films, having again a typical thickness of a few micrometers, exceed 10^6 A/cm^2 at 77 K and zero external magnetic field. A limiting factor for applications of these processes is their low speed, caused by the cumbersome alignment processes.

Immense efforts are devoted in Asia, the US and in Europe to improve the coated conductor processes. Despite these efforts, possible market applications are at best several years away (see, e.g., "R.F. Service, YBCO confronts life in the slow lane", Science, Vol. 295, page 787, 1 February 2002). The reason is that the texturing of the tapes is a tedious and costly process. Due to this, the maximum length of the coated conductors produced today is approximately ten meters only, and no practical way has been found to produce larger lengths at competitive costs. It is clear that the commercial breakthrough of conductor conductors could be obtained if the current density of the cable could be enhanced significantly for a given grain alignment. Therefore such methods are sought since many years with great intensity as described by P. Grant in "Currents without Borders" Nature Vol. 407, 2000, pp 139-141. If such a method was found, one could benefit for given production costs from an enhanced critical current, or, if the grain alignment was relaxed, from standard critical currents at much lower costs.

A paper by T. Murago, J. Sato, et al., entitled "Enhancement of critical current density for Bi-2212/Ag tape conductors through microstructure control", publishes in Physica C 309 (1998) pp 236-244, discusses tape conductors with various cross sections but does neither address a solution with a plurality of

New page 6a

substrates nor does it address the peculiarities of the materials chosen for implementing the present invention.

The same applies, mutatis mutandis, to WO 01/08169 A2 which discloses coated conductors to be used for power transmission cables, rotor coils of motors and generators, transformers and the like. The specific goal disclosed in this patent application is the minimization of AC losses by using a multilayered tape structure. Though the present invention also concerns a "long" multilayer structure, the WO application concentrates on various coating methods for improving the conduction between the various layers, the disclosed details of which differ significantly from those of the present invention as claimed.

Improved Superconductors and Methods for Making such Superconductors

Complete set of "clean" claims

1. An extended polycrystalline superconductor, e.g. a superconducting tape, wire, or foil,

characterized by

- at least two substrates,
- each said substrate having deposited thereon a superconducting layer, preferably on a buffer layer on said substrate, and
- an extensive superconducting contact established between the surfaces of said superconducting layers and extending over at least a fraction of $f = 0.3$ of the length and width of said superconductor.

2. An extended polycrystalline superconductor, e.g. a superconducting tape, or wire, or foil, *characterized by*

- a length of at least 1 m, preferably several m,
- a substrate having deposited thereon at least one superconducting layer, preferably on a buffer layer on said substrate, and
- an extensive superconducting contact established between the surface(s) of said superconducting layer(s) and extending over at least a fraction of $f = 0.3$ of the length and width of said superconductor,
- at least one of said superconducting layers comprising a compound belonging to the $ReBa_2Cu_3O_{7-\delta}$ family, Re being a rare earth including La or Y.

3. The superconductor according to claim 1 or 2, *wherein* the superconductor comprises at least two superconducting layers deposited on opposing sides of at least one substrate.

4. The superconductor according to any of the preceding claims, *wherein* the superconductor is rolled, folded or twisted such that the surface(s) of the superconducting layer(s) provide the desired extensive superconducting contact.

5. The superconductor according to any of the preceding claims, *wherein* the superconducting layers in contact are of preferably different lengths or widths and said contact extends at least over a fraction of about $f = 0.5$ of the length and width of one of said superconducting layers.

6. The superconductor according to claim 1, *wherein* the length of said superconductor is at least 1 m, preferably several m.

7. The superconductor according to any of the preceding claims, *wherein* the grains in at least one superconducting layer are aligned so that low-angle grain boundaries are obtained.

8. The superconductor according to any of the preceding claims, *wherein* the average length of the grains in at least one superconducting layer exceeds their average width by at least a factor of 1.5.

9. The superconductor according to any of the preceding claims, *wherein* at least one of the superconducting layers consists of a heterostructure.

10. The superconductor according to claim 9, *wherein* the heterostructure includes at least one doping film.

11. The superconductor according to any of the preceding claims, *wherein* the superconducting contact is established by pressing the superconducting layers together with mechanical means.

12. The superconductor according to any of the claims 1 to 10, *wherein* the superconducting contact is established by sintering and/or soldering the superconducting layers together.

13. The superconductor according to any of the preceding claims, *wherein* the superconducting contact is established by welding the superconducting layers together.

14. The superconductor according to claim 12 or 13, *wherein* the superconducting contact is established while pressure is applied.

15. The superconductor according to any of the claims 11 to 14, *wherein* the superconducting contact is established by providing an intermediate layer, particularly an intermediate layer deposited onto at least one of the superconducting layers.

16. The superconductor according to claim 15, *wherein* the intermediate layer comprises a powder deposited onto at least one of the superconducting layers.

17. The superconductor according to any of the preceding claims, *wherein* at least one of the substrates is removed before establishing the superconducting contact between the surfaces of the superconducting layers.

18. The superconductor according to any of the preceding claims, *wherein* at least one superconducting layer is separated into pieces before establishing the superconducting contact.

19. The superconductor according to any of the preceding claims, *wherein* at least one of the superconducting compounds used in any of the superconducting layers is a cuprate.

20. The superconductor according to claim 1, *wherein* at least one of the superconducting compounds used in any of the superconducting layers belongs to the $ReBa_2Cu_3O_{7-\delta}$ family, Re being a rare earth including La or Y.

21. The superconductor according to claim 20, *wherein*
- metallic substrates are provided,
- the superconducting compound of the $ReBa_2Cu_3O_{7-\delta}$ family is deposited on both sides of said substrates, preferably onto buffer layers, and
- at least two of these substrates carrying superconducting layers are mounted on top of each other over at least a third of their length or width.

22. A method for making an extended superconductor, e.g. a wire, tape, or foil, *characterized by*
- depositing at least two superconducting layers onto at least one substrate, preferably onto an intermediate buffer layer on said substrate,
- establishing an extensive superconducting contact between the surfaces of said superconducting layers, said superconducting contact extending over at least a predetermined fraction of the length and width of said superconducting layers.

23. *(amended)* A method for making an extended superconductor, e.g. a wire, tape, or foil, *characterized by*
- providing at least one substrate of a length of at least 1 m, preferably several m,
- depositing at least one superconducting layer onto said substrate, preferably onto an intermediate buffer layer on said substrate,
- rolling, folding and/or twisting said at least one substrate for establishing an extensive superconducting contact between the surfaces of said superconducting layer(s), said superconducting contact extending over at

least a predetermined fraction of the length and width of said superconducting layer(s),

- at least one of said superconducting layers comprising a compound belonging to the $ReBa_2Cu_3O_{7-\delta}$ family, Re being a rare earth including La or Y.

24. The method for making a superconductor according to claim 23, *wherein*
- a single substrate is used,
- said substrate is rolled, folded or twisted such that one part of the superconducting layer contacts another part of the same or another superconducting layer to establish the desired extensive superconducting contact between the surfaces of said superconducting layers.

25. The method for making a superconductor according to claim 22 or 23, *wherein*

the superconducting layer is obtained by

- depositing a superconducting compound onto a substrate, preferably onto a buffer layer on said substrate, thus producing a multilayer and
- subsequently separating or splicing the multilayer obtained this way.